CHAPTER 5

LUBRICATING SYSTEMS

Although the oil system of the modern gas turbine engine is varied in design and plumbing most have units which perform similar functions. In most cases a pressure pump or system furnishes oil to the engine to be lubricated and cooled. A scavenging system returns the oil to the tank for reuse. The problem of overheating is more severe after the engine has stopped than while it is running. Oil flow which would normally have cooled the bearings has stopped. Heat stored in the. turbine wheel will raise the bearing temperature much higher than that reached during operation. Most systems will include a heat exchanger (air or fuel) to cool the oil. Many are designed with pressurized sumps. Some incorporate a pressurized oil tank. This ensures a constant head pressure to the pressure- lubrication pump to prevent pump cavitation at high altitude.

Oil consumption in a gas turbine engine is low compared to that in a reciprocating engine of equal power. Oil consumption on the turbine engine is affected by the efficiency of the seals. However, oil can be lost through internal leakage and on some engines by malfunction of the pressurizing or venting system. Oil scaling is very important in a jet engine. Any wetting of the blades or vanes by oil vapor will encourage the accumulation of dust and dirt. A dirty blade or vane represents high friction-to-airflow. This decreases engine efficiency, and results in a noticeable decrease in thrust or increase in fuel consumption. Since oil consumption is so low, oil tanks can be made relatively small. This causes a decrease in weight and storage problems. Tanks may have capacities ranging from 1/2 to 8 gallons. System pressures may vary from 15 psig at idle to 200 psig during cold starts. Normal operating pressures and bulk temperatures are about 50 to 100 psig and 200°F, respectively.

GENERAL

In general the parts to be lubricated and cooled include the main bearings and accessory drive gears and the propeller gearing in the turboprop. This represents again in gas turbine engine lubrication simplicity over the complex oil system of the reciprocating engine. The main rotating unit can be carried by only a few bearings. In a piston power plant there are hundreds more moving parts to be lubricated. On some turbine engines the oil may also be uscd–

- To operate the servo mechanism of some fuel controls.
- To control the position of the variable area exhaust-nozzle vanes.
- To operate the thrust reverser.

Because each bearing in the engine receives its oil from a metered or calibrated orifice, the system is generally known as the calibrated type. With a few exceptions the lubricating system used on the modem turbine engine is of the dry-sump variety. However, some turbine engines are equipped with a combination dry- and wet-type lubrication system. Wet-sump engines store the lubricating oil in the engine proper. Dry-sump engines utilize an external tank usually mounted on or near the engine. Although this chapter addresses dry-sump systems, an example of the wet-sump design can be seen in the Solar International T-62 engine. In this engine the oil reservoir is an integral part of the accessory-drive gear case. An example of a combination dry- and wet-sump lubrication can be found in the Lycoming T-55-series engines.

TURBINE ENGINE DRY-SUMP LUBRICATION

In a turbine dry-sump lubrication system, the oil supply is carried in a tank mounted externally on or near the engine. With this type of system, a larger oil supply can be carried and the oil temperature can be controlled An oil cooler usually is included in a dry-sump oil system (Figure 5-l). This cooler may be air-cooled or fuel-cooled. The dry-sump oil system allows the axial-flow engines to retain their comparatively small diameter. This is done by designing the oil tank and the oil cooler to conform to the design of the engine.

The following component descriptions include most of those found in the various turbine lubrication systems. However, not all of these components will be found in any one system.

The dry-sump systems use an oil tank which contains most of the oil supply. However, a small sump usually is included on the engine to hold a supply of oil for an emergency system. The dry-sump system usually contains –

- Oil pump.
- Scavenge and pressure inlet strainers.
- Scavenge return connection.
- Pressure outlet ports.
- Oil falter.
- Mounting bosses for the oil pressure transmitter.
- Temperature bulb connections.

A typical oil tank is shown in Figure 5-2. It is designed to furnish a constant supply of oil to the engine. This is done by a swivel outlet assembly mounted inside the tank a horizontal baffle mounted in the center of the tank, two flapper check valves mounted on the baffle, and a positive-vent system.

The swivel outlet fitting is controlled by a weighted end, which is free to swing below the baffle. The flapper valves in the baffle are normally open. They close only when the oil in the bottom of the tank rushes to the top of the tank during deceleration. This traps the oil in the bottom of the tank where it is picked up by the swivel

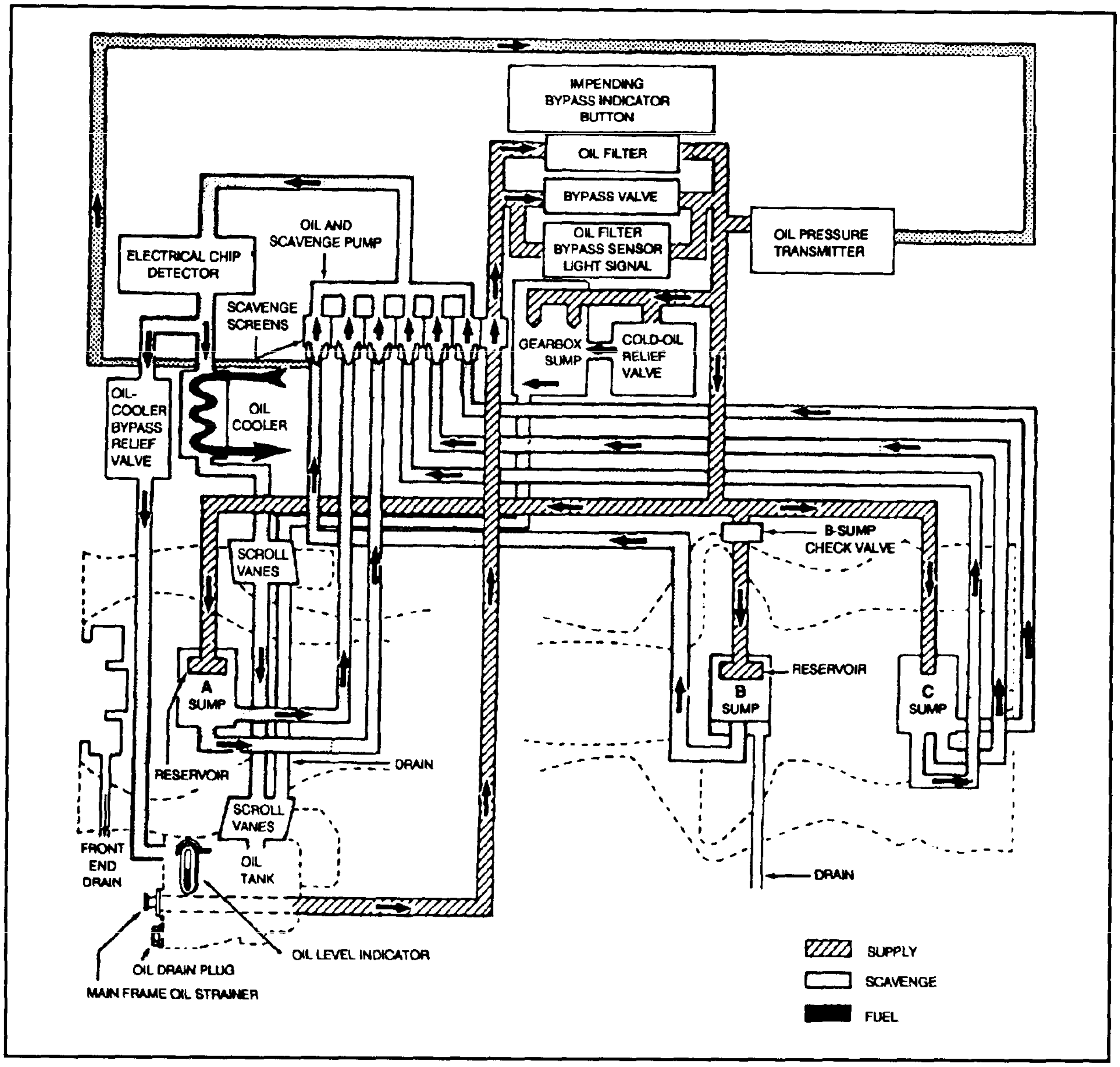

Figure 5-1. Oil System Schematic

fitting A sump drain is located in the bottom of the tank. The airspace is vented at all times.

All oil tanks have expansion space. This allows for oil expansion after heat is absorbed from the bearings and gears and after the oil foams after circulating through the system. Some tanks also incorporate a deaerator tray. The tray separates air from the oil returned to the top of the tank by the scavenger system. Usually these deaerators are the "can" type in which oil enters a tangent. The air released is carried out through the vent system in the top of the tank. Inmost oil tanks a pressure buildup is desired within the tank. This assures a positive flow of oil to the oil pump inlet. This pressure buildup is made possible by running the vent line through an adjustable check-relief valve. The check-relief valve normally is set to relieve at about 4 psi pressure on the oil pump inlet.

There is little need for an oil-dilution system. If the air temperature is abnorrnally low, the oil may be changed to a lighter grade. Some engines may provide for the installation of an immersion-type oil heater.

TURBINE ENGINE WET-SUMP LUBRICATION

In some engines the lubrication system is the wet-sump type. Because only a few models of centrifugal-flow engines are in operation, there are few engines using a wet-sump type of oil system.

The components of a wet-sump system are similar to many of a dry-sump system. The oil reservoir location is the major difference.

The reservoir for the wet-sump oil system may be the accessory gear case, which consists of the accessory gear casing and the front compressor bearing support casing. Or it may be a sump mounted on the bottom of the accessory case. Regardless of configuration reservoirs for wet-sump systems are an integral part of the engine and contain the bulk of the engine oil supply.

The following components are included in the wet-sump reservior:

- A bayonet-type gage indicates the oil level in the sump.
- Two or more finger strainers (filters) are inserted in the accessory case for straining pressure and scavenged oil before it leaves or enters the sump. These strainers aid the main oil strainer.
- A vent or breather equalizes pressure within the accessory casing.
- A magnetic drain plug may be provided to drain the oil and to trap any ferrous metal particles in

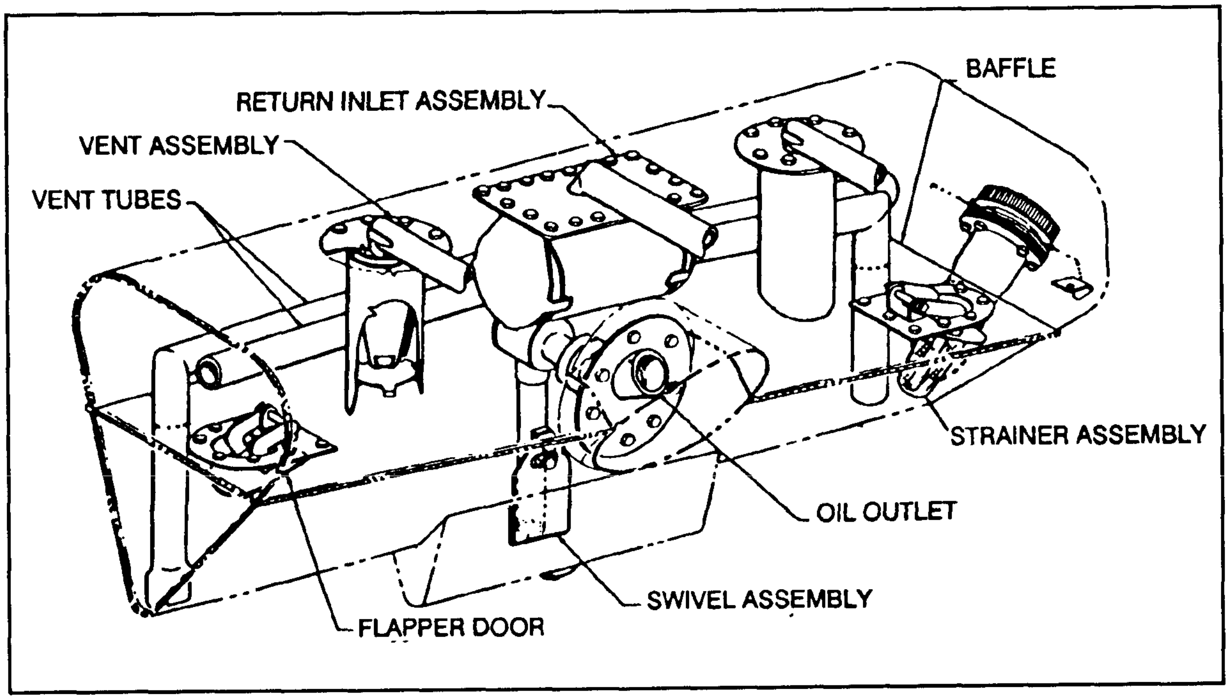

Figure 5-2. Oil Tank

the oil. This plug should always be examined closely during inspections. The presence of metal particles may indicate gear or bearing failure.

- A temperature bulb and an oil pressure fitting may be provided.

This system is typical of all engines using a wet-sump lubrication system. The bearing and drive gears in the accessory drive casing are lubricated by a splash system. The oil for the remaining points of lubrication leaves the pump under pressure. It passes through a falter to jet nozzles that direct the oil into the rotor bearings and couplings. Most wet-sump pressure systems are variable-pressure systems in which the pump outlet pressure depends on the engine RPM.

The scavenged oil is returned to the reservior (sump) by gravity and pump suction. Oil from the front compressor bearing in the accessory-drive coupling shaft drains directly into the reservoir. Oil from the turbine coupling and the remaining rotor shaft bearings drains into a sump. The oil is then pumped by the scavenge element through a finger screen into the reservoir.

OIL SYSTEM COMPONENTS

The oil system components used on gas turbine engines are–

- Tanks.
- Pressure pumps.
- Scavenger pumps.
- Filters.
- Oil coolers.
- Relief valves.
- Breathers and pressurizing components.
- Pressure and temperature gages and warning lights.
- Temperature-regulating valves.
- Oil-jet nozzle.
- Fittings, valves, and plumbing.
- Chip detectors.

Not all of the units will be found in the oil system of any one engine. But a majority of the parts listed will be found in most engines.

Oil Tanks

Tanks can be either an airframe or engine-manufacturer-supplied unit. Usually constructed of welded sheet aluminum or steel, it provides a storage place for the oil. Inmost engines the tank is pressurized to ensure a constant supply of oil to the pressure pump. The tank can contain–

- Venting system.
- Deaerator to separate entrained air from the oil.
- Oil level transmitter or dipstick.
- Rigid or flexible oil pickup.
- Coarse mesh screens.
- Various oil and air inlets and outlets.

Pressure Pumps

Both gear- and Gerotor-type pumps are used in the lubricating system of the turbine engine. The gear-type pump consists of a driving and a driven gear. The engine-accessory section drives the rotation of the pump. Rotation causes the oil to pass around the outside of the gears in pockets formed by the gear teeth and the pump casing. The pressure developed is proportional to engine RPM up to the time the relief valve opens. After that any further increase in engine speed will not result in an oil pressure increase. The relief valve may be located in the pump housing or elsewhere in the pressure system for both types of pumps.

The Gerotor pump has two moving parts: an inner-toothed element meshing with an outer-toothed element. The inner element has one less tooth than the outer. The missing tooth provides a chamber to move the fluid from the intake to the discharge port. Both elements are mounted eccentrically to one another on the same shaft.

Scavenger Pumps

These pumps are similar to the pressure pumps but have a much larger total capacity. An engine is generally provided with several scavenger pumps to drain oil from various parts of the engine. Often one or two of the scavenger elements are incorporated in the same housing as the pressure pump (Figure 5-3). Different capacities can be provided for each system despite the common driving shaft speed. This is accomplished by varying the diameter or thickness of the gears to vary the volume of the tooth chamber. A vane-type pump may sometimes be used

Oil Filters and Screens or Strainers

To prevent foreign matter from reaching internal parts of the engine, falters and screens or stainers are provided in the engine lubricating system. The three basic types of oil falters for the jet engine are the cartridge screen-disq and screen (Figures 5-4, 5-5 and 5-6). The cartridge falter is most commonly used and must be replaced periodically. The other two can be cleaned and

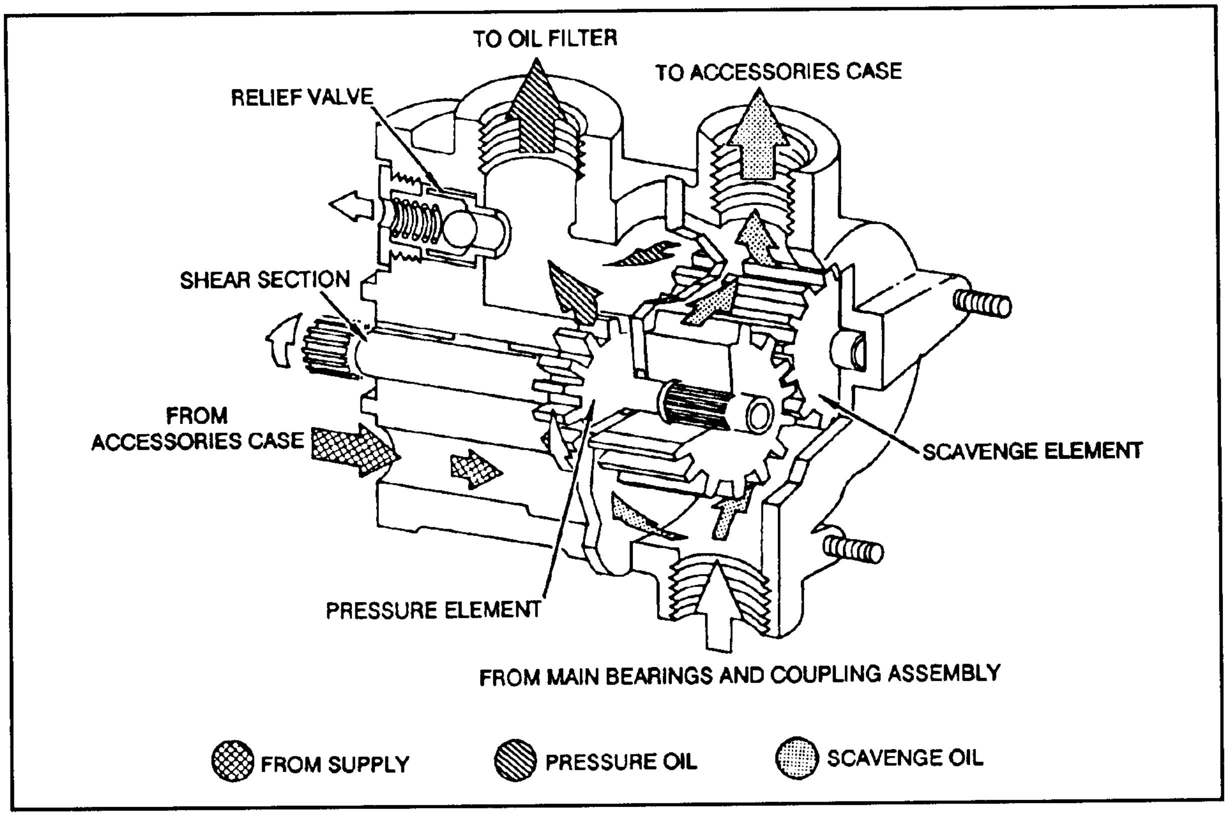

Figure 5-3. Cutaway View of Gear Oil Pump

reused. In the screen-disc falter there are a series of circular screen-type falters. Each falter is comprised of two layers of mesh forming a chamber between mesh layers. The filters are mounted on a common tube and arranged to provide a space between each circular element. Lube oil passes through the circular mesh elements and into the chamber between the two layers of mesh. This chamber is ported to the center of a common tube which directs oil out of the falter. Screens or strainers are placed at pressure oil inlets to bearings in the engine. This aids in preventing foreign matter from reaching the bearings.

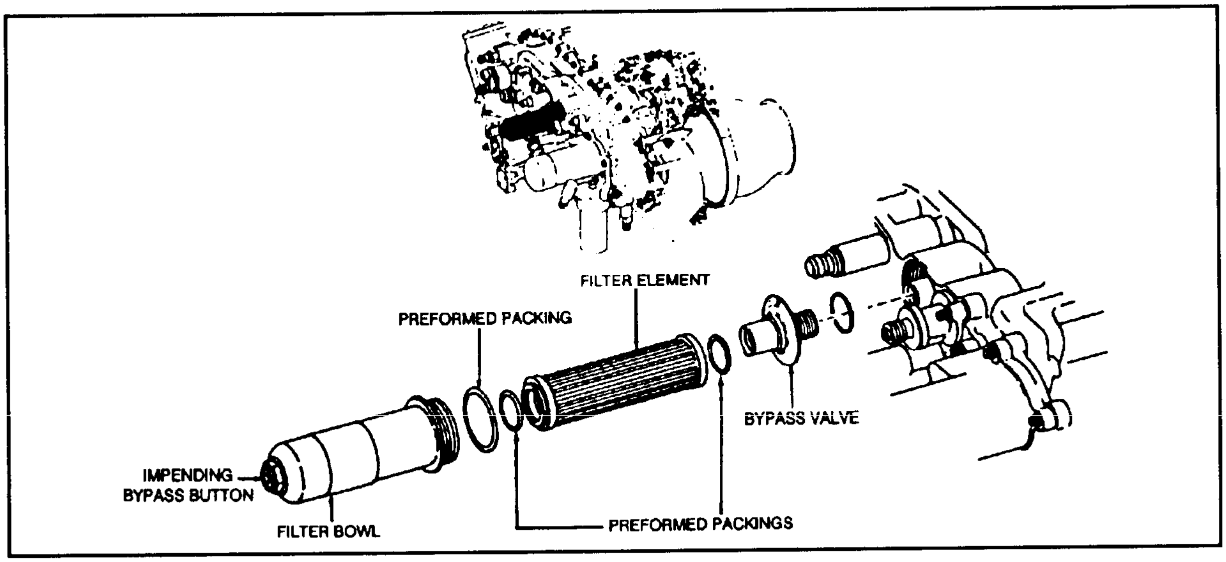

Figure 5-4. Cartridge-Type Filter Assembly

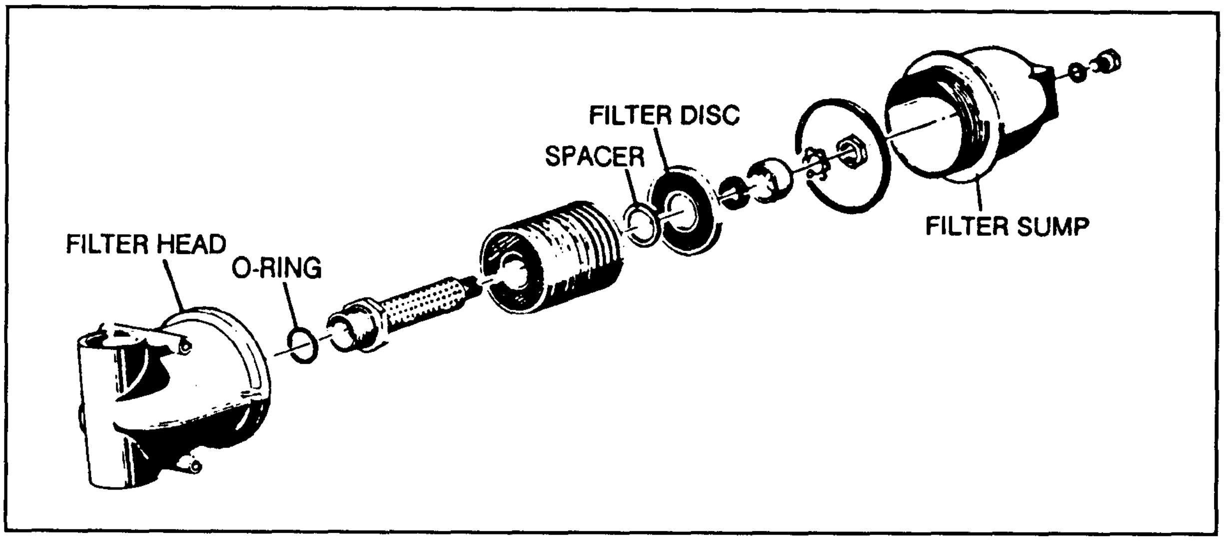

Figure 5-5. Disc-Type Filter Assembly

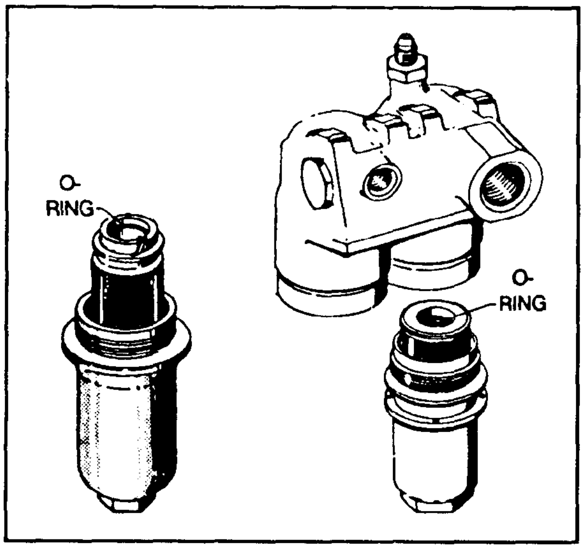

Figure 5-6. Filtering Assembly Screen or Strainer Type

To allow for oil flow in the event of filter blockage, all falters incorporate a bypass or relief valve as part of the falter or in the oil passages. When the pressure differential reaches a specified value (about 15 to 20 psi), the valve opens and allows oil to bypass the filter. Some falters incorporate a check valve. This prevents reverse flow or flow through the system when the engine is stopped Filtering characteristics vary, but most falters will stop particles of approximately 50 microns.

Magnetic Chip Detector

One or more magnetic chip detectors are installed on gas turbine engines. They are used to detect and attract ferrous material (metal with iron as its basic element) which may come from inside the engine. This ferrous material builds up until it bridges a gap. Whenever there is a requirement, the chip detectors may be collected and analyzed to determine the condition of the engine. Most engines utilize an electrical chip detector, located in the scavenger pump housing or in the aceessory gearbox. Should the engine oil become contaminated with metal particles, the detector will catch some of them. This causes the warning light on the caution panel to come on.

Tubing, Hose, and Fittings

Tubing hose, and fittings are used throughout the lubricating system. Their purpose is to connect apart into a system or to connect one part to another to complete a system.

Oil Pressure Indicating System

In a typical engine oil pressure indicating system the indicator receives inlet oil pressure indications from the oil pressure transmitter and provides readings in pounds per square inch Electrical power for oil pressure indicator and transmitter operation is supplied by the 28-volt AC system.

Oil-Pressure-Low Caution Light

Most gas turbine engine lubricating systems incorporate an engine oil-pressure-low caution light warning device into the system for safety purposes. The light is connected to a low-pressure switch. When pressure drops below a safe limit, the switch closes an electrical circuit causing the caution light to bum. Power is supplied by the 28-volt DC system.

Oil Temperature Indicating System

In a typical engine oil temperature indicating system, the indicator is connected to and receives temperature indications from an electrical resistance-type thermocouple or thermobulb. These are located in the pressure pump oil inlet side to the engine. Power to operate this circuit is supplied by the 28-volt DC system.

Oil Coolers

The oil cooler is used to reduce oil temperature by transmitting heat from the oil to another fluid usually fuel. Since the fuel flow through the cooler is much greater than the oil flow, the fuel is able to absorb a considerable amount of heat. This reduces the size and weight of the cooler. Thermostatic or pressure-sensitive valves control the oil temperature by determining whether the oil passes through or bypasses the cooler. Oil coolers are also cooled by air forced through them by a blower/fan.

Breathers and Pressurizing Systems

Internal oil leakage is kept to a minimum by pressurizing the bearing sump areas with air that is bled off the compressor (Figure 5-7). The airflow into the sump minimizes oil leakage across the seals in the reverse direction.

The oil scavenge pumps exceed the capacity of the lubrication pressure pump They are capable of handling considerably more oil than actually exists in the bearing sumps and gearboxes. Because the pumps area constant-displacement type, they make up for the lack of oil by pumping air from the sumps. Large quantities of air are delivered to the oil tank. Sump and tank pressures are maintained close to one another by a line which connects the two. If the sump pressure exceeds the tank pressure, the sump vent check valve opens, allowing the excess sump air to enter the oil tank. The valve allows flow only into the tank; oil or tank vapors cannot back up into the sump areas. Tank pressure is maintained little above ambient.

The scavenge pumps and sump-vent check valve funtions result in relatively low air pressure in the sumps and gearboxes. These low internal sump pressures allow air to flow across the oil seals into the sumps. This airflow minimizes lube oil leakage across the seals. For this reason it is necessary to maintain sump pressures low enough to ensure seal-air leakage into the sumps. Under some conditions, the ability of the scavenge pumps to pump air forms a pressure low enough to cavitate the pumps or cause the sump to collapse. Under other conditions, too much air can enter the sump through worn seals.

If the seal leakage is not sufficient to maintain proper internal pressure, check valves in the sump and tank pressurizing valves open and allow ambient air to enter the system. Inadequate internal sump and gearbox pressure may be caused by seal leakage. If that occurs, air flows from the sumps, through the sump-vent check valve, the oil tank, the tank and sump pressurizing valves to the atmosphere. Tank pressure is always maintained a few pounds above ambient pressure by the sump and tank pressurizing valve.

The following adresses two types of lubrication systems used in the Army today the General Electric T-701 turboshaft engine and the International/Solar T-62-series engine.

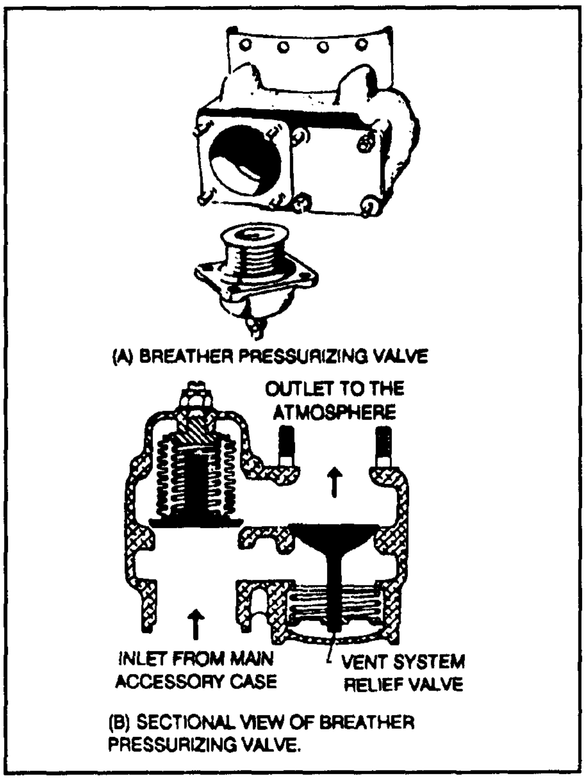

Figure 5-7. Breather Pressurizing Valve

TYPICAL OIL SYSTEM FOR T-701

The lubrication system in the T-700-GE-701 engine distributes oil to all lubricated parts (Figure 5-8). In emergencies it supplies an air-oil mist to the main shaft bearings in the A- and B-sumps. The system is a self-contained, recirculating dry-sump system. It consists of the following subsystems and components:

- Oil supply and scavenge pump.
- Seal pressurization and sump venting
- Emergency lube system.
- Oil filtration and condition monitoring.
- Tank and air-oil cooler.
- Oil cooler.
- Oil pressure monitoring.
- Cold oil-relief and cooler-bypas valves.
- Chip detector.
- Integral accessory gearbox

installed on each side of the tank. A coarse pickup screen located near the tank bottom keeps sizable debris from entering the lube supply pump inlet. A drain plug is located at the bottom of the tank.

Oil from the pickup screen enters a east passage in the mainframe. It is then conducted to the top of the engine to a point beneath the lube supply pump. A short connector tube transfers the oil from the mainframe to the accessory gearbox pump inlet port. The connector tube contains a domed, coarse-debris screen. The screen keeps foreign objects out of the passage when the accessory module is not installed on the mainframe. Oil flows through the connector tube to the pump inlet. There it enters the pump tangentially in alignment with pump rotational direction.

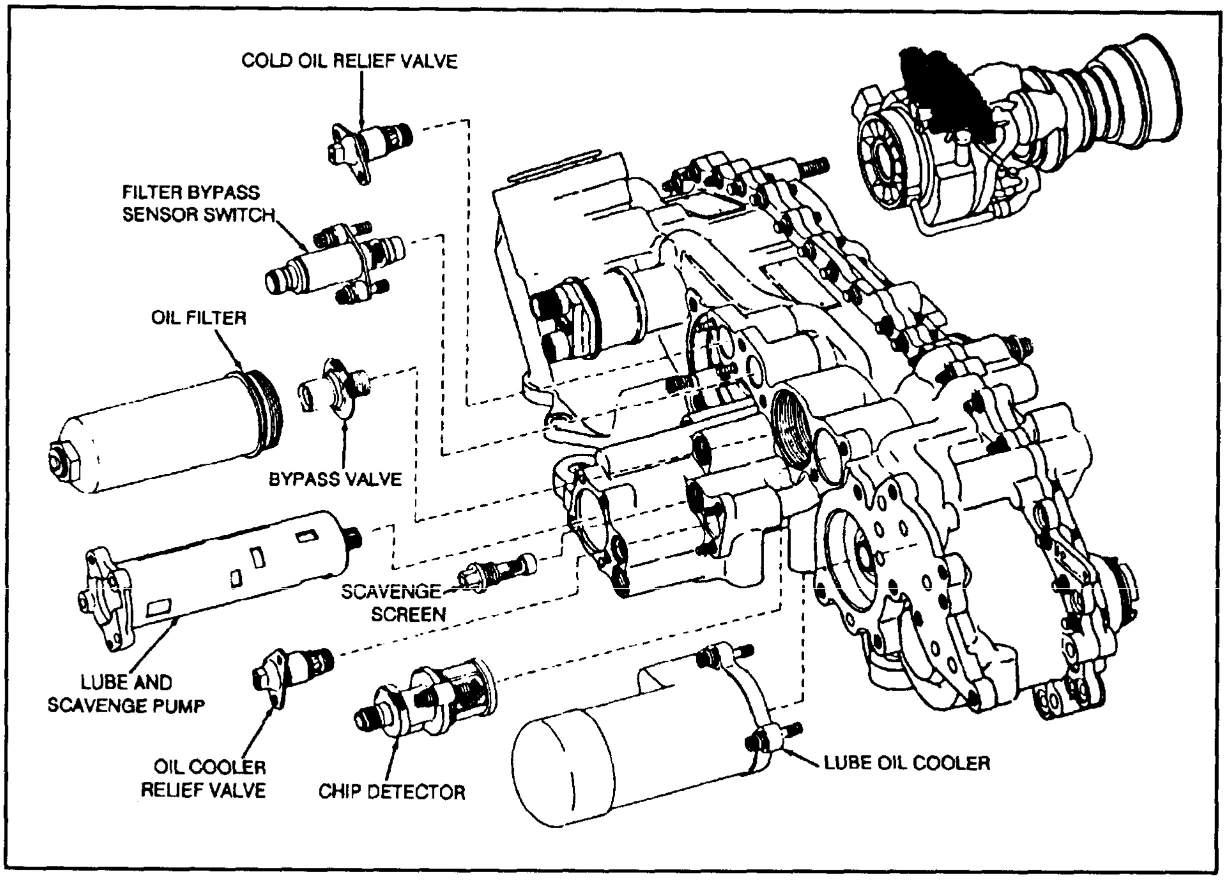

Figure 5-8. Lubrication System Components

Lube Supply System

The oil tank, integral with the mainframe, holds approximately 7.3 quarts of oil (Figure 5-9). This is a sufficient quantity to lubricate the required engine parts without an external oil supply. The tank is filled using a 3-inch, gravity-fill port on the right-hand side. Visual indication of oil level is supplied by a fluid level indicator

The lube supply pump, a Geroter-type pumping element assembly, is comprised of an inner and outer element. The element assembly is located adjacent to the drive spline end of the pump. Six scavenge elements are also located in tandem on the common drive shaft. The stack of pump elements is retained in a cast tubular hosing having an integral end plate. The complete pump slides into a precision bore in the gearbox casing. Oil from the supply pump flows to the lube filter inlet and through the

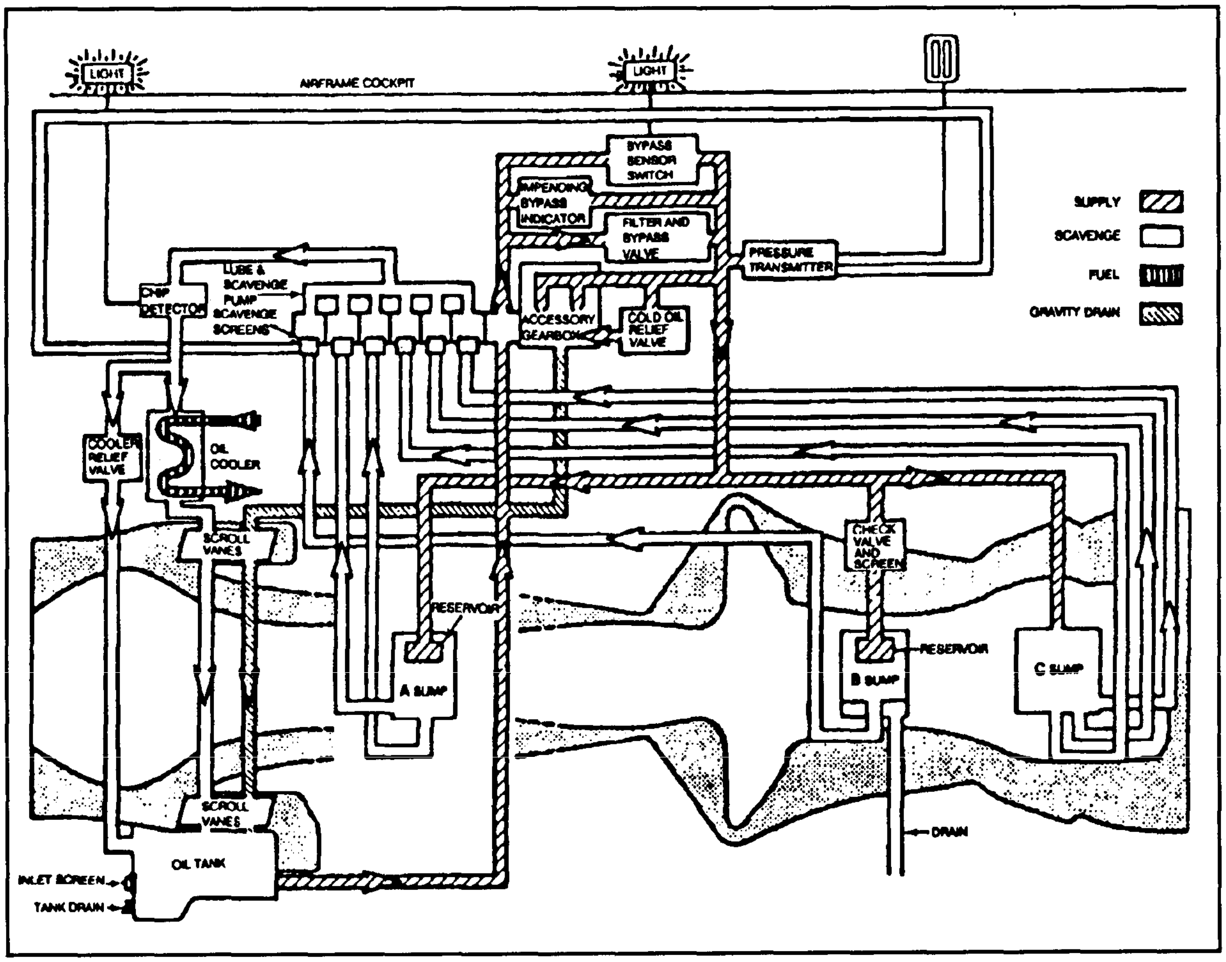

Figure 5-9. Lubrication System Schematic

falter, a 3-micron falter element. Oil flow passes from outside to inside of the falter element. It then passes through the open bore of the bypass valve and into the gearbox outlet passage. Bypass valve opening occurs when filter differential pressure unseats a spring-loaded poppet from its scat. The filter bowl contains an impending bypass warning button which will provide an indication for filter servicing. An electrical bypass sensor for cockpit indication of falter bypass tits into an AGB boss adjacent to the lube falter. A differential pressure of 60-80 psi across the falter will actuate this sensor.

A spring-loaded poppet-type, cold oil relief valve is incorporated in this sytem. This valve prevents excessive supply pressure during cold starts when high oil viscosity creates high line pressures. Cracking pressure is set for 120-180 psid and reset is 115 psid minimum. When open, apart of the lube flow is discharged into the AGB where churning in the gears will assist in reducing warm-up time.

Oil leaving the falter branches in three directions. It goes to the to of the emergency oil reservoirs in the A- and B-sumps, the AGB, and C-sump jets.

Scavenge System. After the oil has lubricated and cooled the parts, the scavenge system returns it to the oil tank (Figure 5-10). In addition, fuel-oil and air-oil coolers and a chip detector are located in the scavenge return path.

Scavenge Inlet Screens. Each scavenge pump inlet is fitted with a relatively coarse screen (Figure 5-11). This screen is designed to protect the pumps from foreign object damage and to provide for fault isolation. Scavenge oil (and air) enters the bore of each screen axially on the open inner end. It exits into a cast annulus which discharges directly into the scavenge pump inlet.

These screens may be removed for inspection if chip generation is suspected

Scavenge pumps. Six scavenge pumps are in line with the lube supply pump on a common shaft (Figure 5-10). Positioning of the pump elements is determined by these factors:

- The lube supply element is placed in the least vulnerable location and isolated from scavenge elements atone end
- The B-sump element is placed at the other end of the pump to help isolate it from the other scavenge elements. This element is the only one with an elevated inlet pressure.
- Pump windmilling experience on other engine scavenge pumps shows that adjacent pumps tend to cut each other off due to interelement leaks at very low speed Therefore, the two A-sump elements are placed adjacent, as are the three C-sump elements, to reduce the possibiity of both elements in a sump being inoperative simultaneously.
- Porting simplification for the gearbox coring determines relative positions of A-sump, B-sump, and C-sump elements.

Scavenge Discharge Passage. The common discharge of all six scavenge pumps is cast into the gearbox at the top of the pump cavity. Top discharge facilitates priming by clearing air bubbles and by wetting all pumping elements from the discharge of first pumps to prime. The discharge cavity is tapered to enlarge as each pump discharge enters the flow steam. This keeps discharge velocity relatively constant. It also tends to avoid air traps which could short-circuit pumping at windmilling speeds. This discharge plenum flows into the core to the chip detector. Flow leaving the chip detector passes to the fuel-oil cooler in series with the air-oil cooler. To promote faster warm-up and guard against plugged coolers, a bypass valve is provided which bypasses both coolers. Air-oil cooling is an integral part of the mainframe casting. Scavenge oil enters a manifold at the tank top. It then flows in a serpentine fashion in and out through the hollow scroll vanes and box-sectioned hub. Air for the particle separator is pulled across the vanes by the scavenge air blower providing the oil cooling process. Exit from the air-oil cooler is through three holes at the top of the tank. These outlets disperse the oil over the tank surfaces on both sides to settle in the tank. The oil tank vents to the AGB.

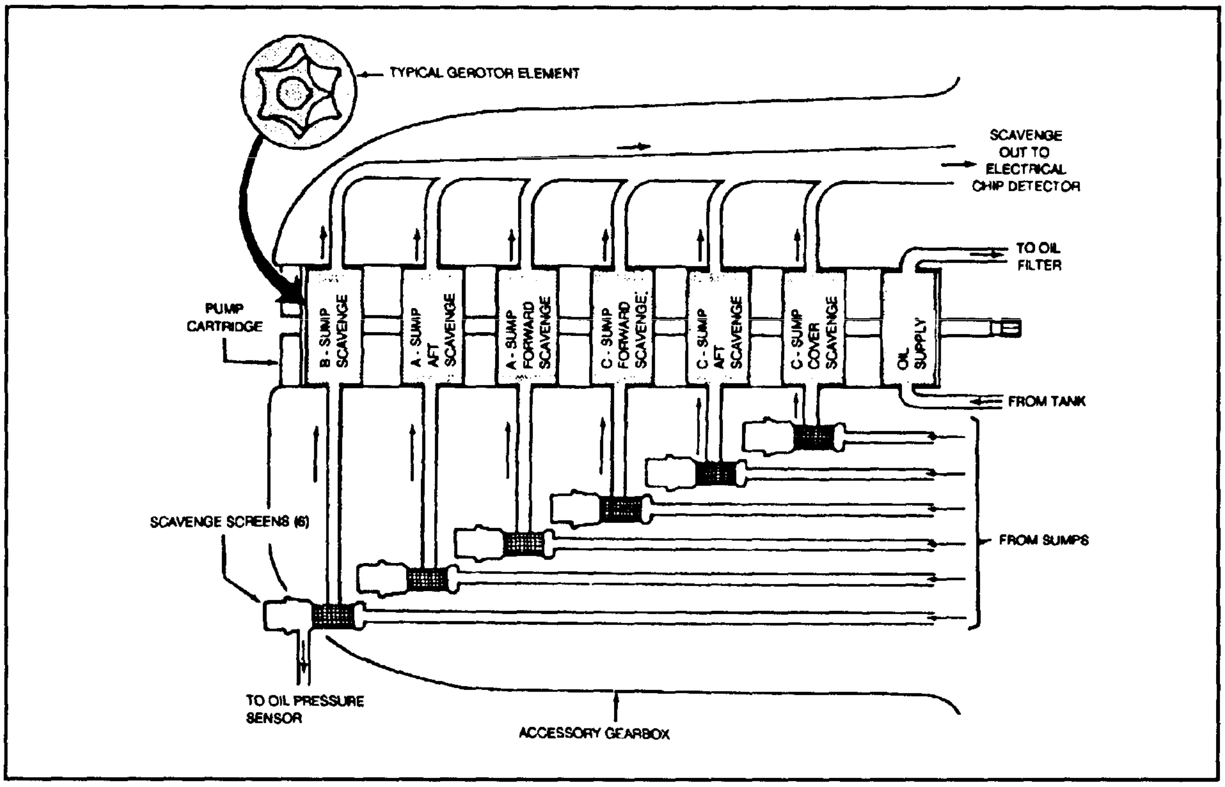

Figure 5-10. (T-701) Oil and Scavenge Pump

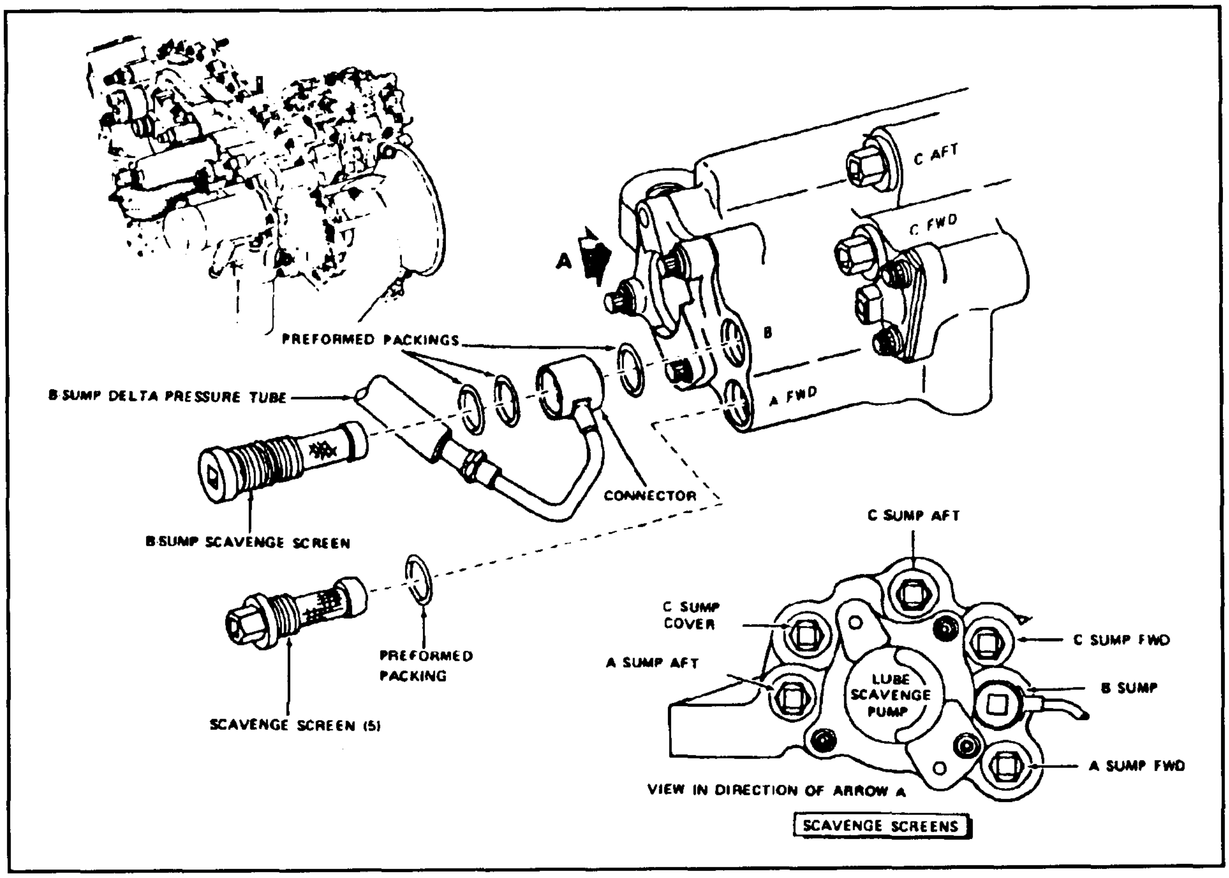

Figure 5-11. Scavenge Screens

Emergency Oil System

The T-700-GE-701 engine is designed to have two oil jets to provide each main bearing with oil for lubricating and cooling (Figure 5-12).

In addition to being designed for normal engine operation, the system provides for operation if the normal oil supply from the primary system is interrupted. The AGB and C-sump components can continue to operate at least 6 minutes with residual oil present. The No. 4 bearing in the B-sump and the bearings and gears in the A-sump are provided with emergency air-oil mist syterns located in each sump. The emergeney oil system forms part of the normal full-time lubrication system and incorporates one full set of main bearing oil jets operating in parallel with the primary jets. The dual-jet system also provides redundancy to minimize the effect of oil jet plugging.

A small reservoir, curved to tit the A- and B-sumps, retains a sufficient amount of oil to provide air-oil mist when normal lubrication is interrupted The total sump oil supply is fed into the reservoir at the top. Top feed prevents reservoir drainage if the supply line is damaged Primary oil jets, squeeze film damper, and uncritical lube jets are connected to a standpipe at the top of the tank. Secondary or emergency jets are similarly connected to the lowest point in the tank.

Secondary jets are only located at points where lubrication is vital for short-duration emergeney operation. Each secondary oil jet has a companion air jet or air source which flows over the end of the oil jet and impinges on the lubricated part. The air jets aspirate oil mist when normal oil supply pressure is lost. They are pressurized from the seal pressurization cavities and operate continuously with no valving required.

Component Description

The oil filter (Figure 5-13) consists of three subassemblies:

- Filter element.
- Bowl and impending bypass indicator.
- Bypass valve and inlet screen.

Filter Element. Media used in this falter are high-temperature materials em-staining organic and inorganic fibers. The layered media are faced on both sides with stainless steel mesh. This mesh provides mechanical support to resist collapse when pressure loads become high. Pleating of the faced media adds surface area and mechanical rigidity. A perforated steel tube in the bore also adds rigidity and retains the circular shape of the element.

The media and support tube are epoxy-bonded to formed sheet metal and caps. These end caps include an O-ring groove which seals inlet to outlet leak paths at each end

Filtration level selected is 100 percent of all particles three microns or larger and is disposable when saturated

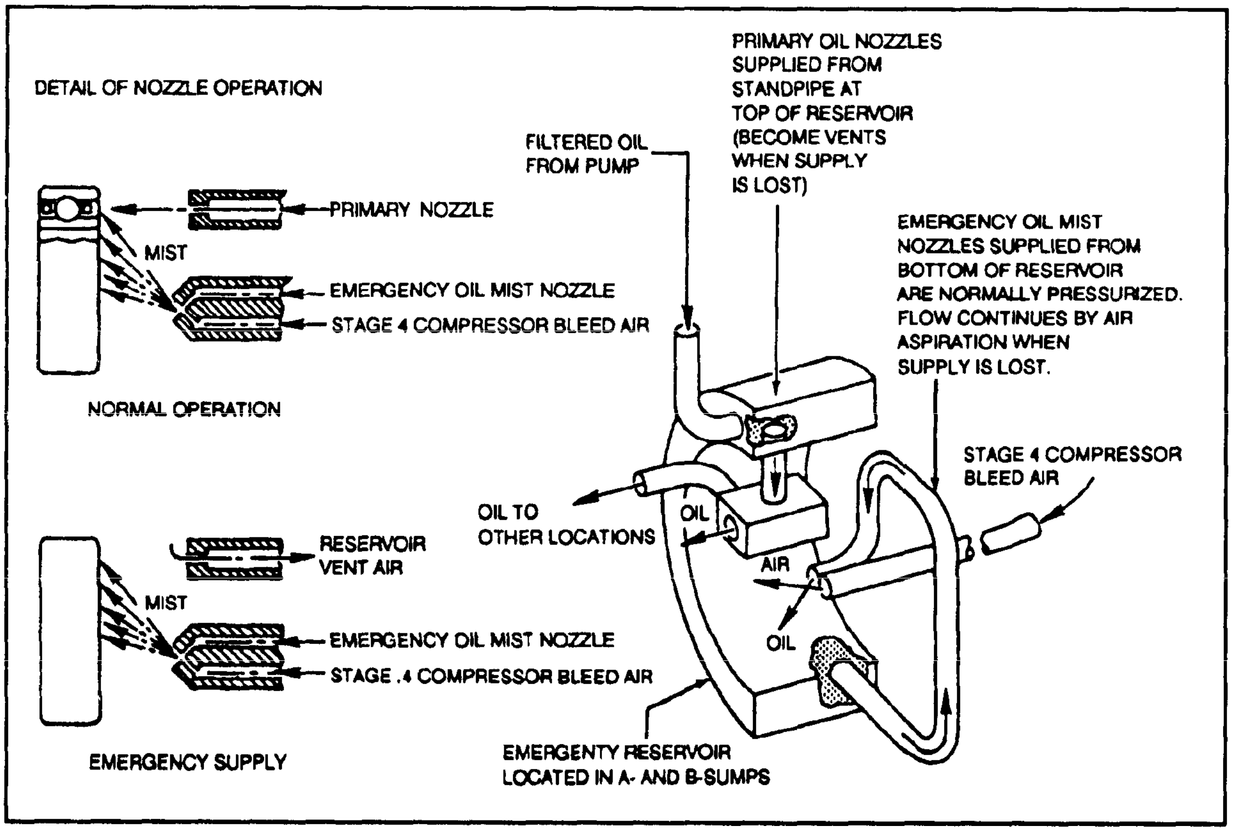

Figure 5-12. Emergency Oil System

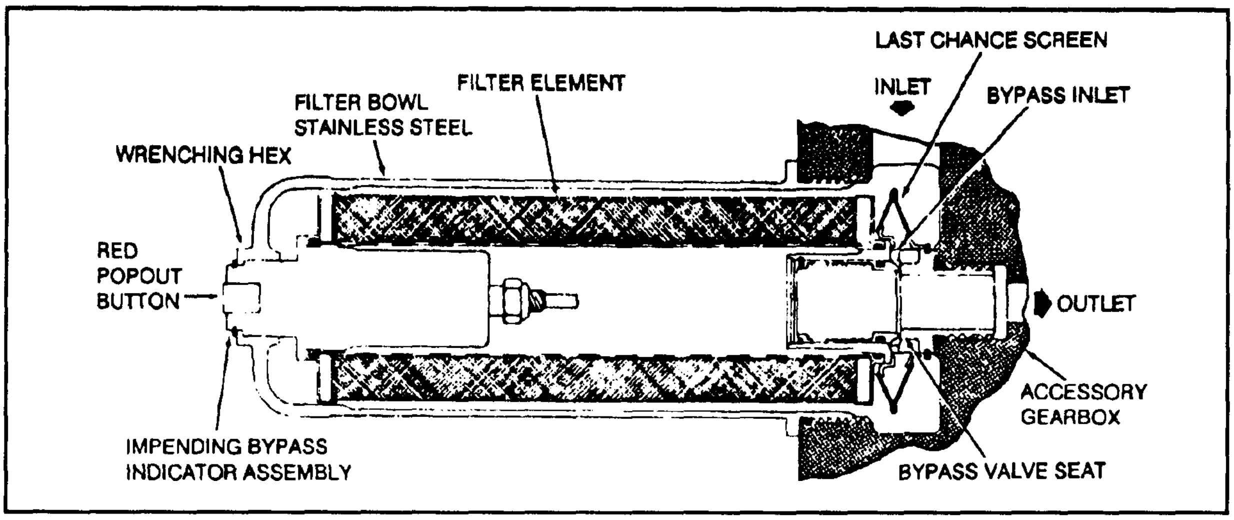

Figure 5-13. Lube Oil Filter (Cross Section)

with debris. Support of the falter element is provided by the bypass valve on one end and the impending bypass indicator on the other. The indicator end has a spring-loaded sleeve which restrains the filter axially.

Bowl and Bypass Indicator. An aluminum bowl houses the element and contains the impending bypass indicator at the end. Mounting is horizontal to fit the space available and provide ready access for servicing Impending bypass indication is provided by a small unit which is part of the bowl assembly. The indicator is installed from the inside of the bowl. It is retained in place with an external retaining ring. Basic mechanics of operation are as follows:

- Different pressure between filter inlet and outlet acts to move a piston against a spring at 44 to 60 psi.
- Piston contains a magnet which normally attracts a redbutton assembly and holds it seated against its spring. When the piston moves, the button is released. It extends 3/16 inch to visually indicate an impending bypass condition.
- Button is physically reattained from tripping by a cold lockout bimetallic latch if temperature is less than 100 to 130°F. This prevents a false trip during cold starts.
- As the button is released, a small spring-loaded ball also moves out of position to latch the button and block reset. The internal piston assembly automatically resets on shutdown; however, the indicator remains latched out.
- After removing the filter element and the bowl from the gearbox, a spring-loaded sleeve around the indicator moves aft and pulls the piston assembly to a tripped position. This causes the button to trip if operation is attempted with no filter in the bowl.
- To react the indicator, the bowl is held vertically so the button latch ball can roll out of the latched position. The button is then manually reset.

If the bowl is reassembled with no falter, the indicator will trip when the temperature exceeds the 100 to 130°F lock-out level. The internal latch mechanism prevents resetting the button without disassembling the bowl. Resetting must be done with the bowl removed from the accessory gearbox and held verically, button up, to release the latch.

Oil Filter Bypass Sensor. The oil filter bypass sensor is a differential-pressure switch which senses fiilter inlet minus outlet pressure.

The sensor consists of a spring-loaded piston which moves aft at high falter differential pressure (60 to 80 psi) and magnetically releases a microswitch lever. The switch is in a sealed cavity separated from the oil and is wired to a hermetically sealed electrical connector. The switch connects 28-VDC aircraft power when tripped and reopens the circuit at 15 psi minimum differential No latch is used in the sensor so resetting is automatic. Also, there is no cold lockout. The pilot will be informed of falter bypassing during cold start warm-ups. Sensor tolerance range is set slightly below the tolerance range of bypass valve cracking pressure. Therefore, bypassing will not occur without pilot warning. The impending bypass indicator will show need-to-change filter elements. This sensor provides backup warning if maintenance action is not taken.

Lubrication and Scavenge Pump. The lube and scavenge pump is a Gerotor-type pump of cartridge design, located on the forward side of the accessory gearbox (refer back to Figure 5-10). It fits into a precision bore in the gearbox casing. The Gerotor-type pump was chosen because of its wear resistance and efficiency. Gerotor elements are similar to male gear inside a female (internal) gear with one less tooth on the inner member.

The inner Gerotors are keyed to the drive shaft, and the outer Gerotors are pocketed in individual eccentric rings. AS the assembly rotates, oil is drawn into an expanding cavity between teeth on one side. The oil is expelled when the cavity contracts approximately 180° away. Inlet and discharge ports are cast into the port plates. They are shaped and positioned to fill and empty at proper timing for maximum volumetric efficiency and resistance to inlet cavitation.

There are seven different elements in the pump from the spline end forward. They are the lube supply element, C-sump cover, C-sump aft, C-sump forward, A-sump forward, A-sump aft, and B-sump Delta scavenge elements.

The port plate eccentric rings and Gerotors are assembled into a surrounding concentric aluminum tubular housing The housing maintains all elements in proper alignment. The oil suction and discharge passages from the Gerotors are brought radially through the housing. They match the appropriate locations of the mating passages in the engine gearbox casing. The entire stack of port plates is retained in the housing with the retaining rings at the spline end. The outermost end of the housing has an integrally cast cover. The cover bolt holes are arranged to orient the pump assembly in the gearbox housing during installation.

Cold Oil Relief Valve. The cold oil relief valve protects the oil supply system from overpressure during cold starts (refer back to Figure 5-9). It is a conventional poppet-type valve with a cracking pressure of 120-180 psi. Valve tolerances are held sufficiently close to achieve the desired sacking pressure without adjustment shims or selective fitting of parts.

The valve includes a No. 10-32 threaded hole on the outside. This allows for the usc of a bolt as a pulling handle during valve removal from the AGB.

Oil Cooler. The fuel-oil cooler is a tube and shell design (Figure 5-14). It cools the combined output of the scavenge discharge oil that is ported through gearbox-cored passages to the cooler. The cooler is mounted adjacent to the fuel-boost pump on the forward side of the gearbox. Oil and fuel porting enter on the same end via face porting to the gearbox. Fuel is used as the coolant. It is provided to the cooler via the boost pump, fuel falter, and hydromechanical control unit. A counterparallel flow, miltipass cooler design is used to minimize pressure drop while obtaining maximum cooler effectiveness. Fuel flows through the tubes, while the oil flows over the tubes resulting in the counterparallel flow arrangement.

Oil Cooler Bypass Valve. Design of the oil cooler bypass valve is identical to the cold oil relief valve with an exception (refer back to Figure 5-9). A lighter spring is utilized to obtain a lower cracking pressure of 22-28 psi. Housing modifications prevent inadvertent interchange with the cold oil relief valve.

Chip Detector. The chip detector in the common scavenge line is the engine diagnostic device most likely to provide first warning of impending part failure (Figure 5-15).

The chip detector magnetically attracts electrically conductive ferrous chips. The chips bridge the gap between the detector's electrodes and close a circuit in series with the aircraft cockpit indicator (warning light). The chip detecting gap has a magnetic field induced in tapered pose pieces at each end of a cylindrical permanent magnet. A single ferrous chip 0.090 inch in length or longer will be indicated if magnetically attracted to bridge the pole pieces. The local mangetic field is intense at the gap and tends to orient particles in the bridging direction. Smaller particles tend to form chains until the pole pieces are bridged

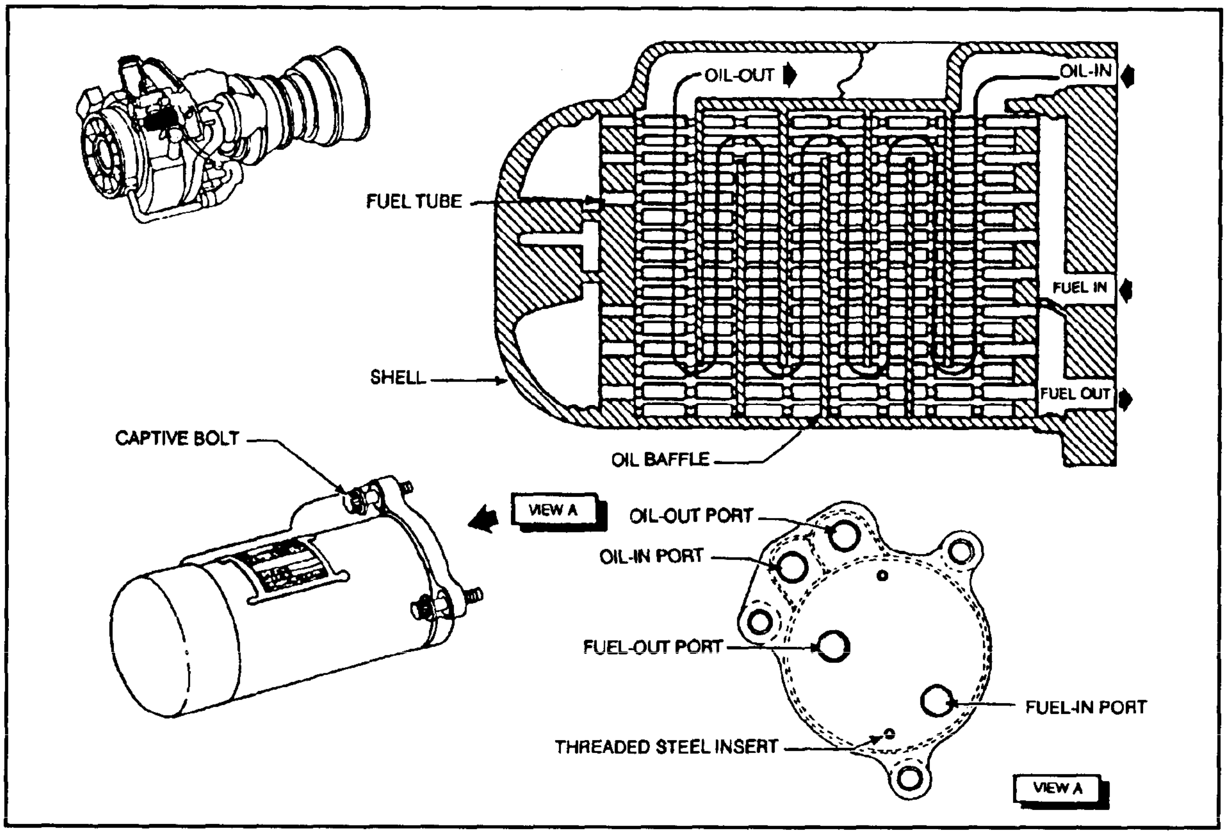

Figure 5-14. Oil Cooler

Nonconductive particles greater than 0.015 inch are trapped inside the screen for visual examination. Smaller particles will be found either in the lube tank or in the lube supply falter.

The detector housing pushes into the accessory gearbox It is retained by two captive bolts used in common with other accessories. Self-locking inserts in the gearbox ensure retention of these bolts if assembly torque is improperly low.

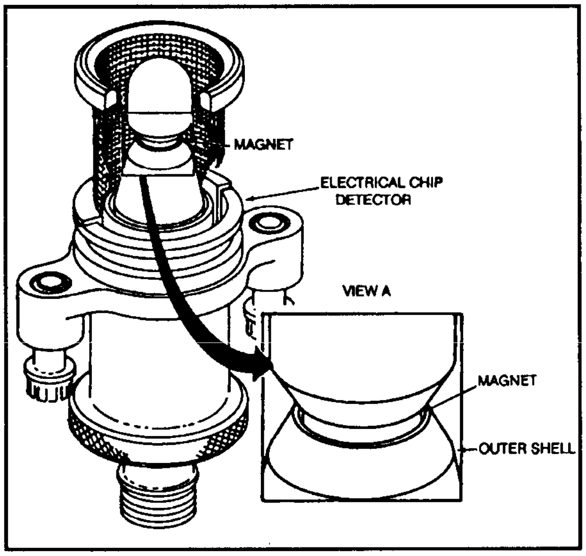

Figure 5-15. Electrical Chip Detector

Venting System

A-Sump. The A-sump centervent handles air-oil separation and overboard venting from these sources:

- A-sump seals and emergency air system.
- Scavenge pumped air from the lube tank.
- Accessory gearbox vent (no air sources).
- B-sump centervent flow which passes through the intershaft seal.

Path of this vent is into the bore of the power turbine shaft and torque-reference tube and out the aft end of the engine through the C-sump cover. The centrifugal air-oil separator vent holes in the power turbine shaft are located under the forward end of the high-speed shaft. Windage from PTO gear locknut wrenching slots assists in turning oil back into the sump. Air from the sump and intershaft seal flows inward radially through these holes in the power turbine shaft. The air must flow forward in the annulus between the power turbine shaft and the torque-reference tube. Movement of air is blocked by a standoff ring on the reference tube OD. The forward axial passage of the air centrifuges oil droplets outward to the bore of the power turbine shaft. They either flow back into the sump at the centervent or at small weep holes forward of the PT shaft spline. Dried air then exits through multiple rows of holes in the reference tube and out the aft C-sump cover. Some remaining oil in this air is spun into the C-Sump if it has condensed in transit. Any additional accumulated oil is then scavenged through the C-sump cover.

B-Sump. A centervent on the forward side of the No. 4 bearing accommodates air entering the sump at the labyrinth seals at each end Two rows of small holes are drilled in a radially thickened section of the forward seal runner. Use of many small holes increases the surface area of metal in contact with exiting oil droplets. These small holes also reduce effective window area for any droplets which may have a trajectory aimed directly at the holes. Ater the air is inside these holes, it follows a tortuous path through additional rows of holes in the turbine shaft and compressor rear shaft. The air then enters the annlus between the high- and low-speed shafts. In doing this, remaining oil is spun back into the sump.

About 70 percent of B-sump centervent flow moves forward through the bore of the compresor tiebolt and intershaft seal. It exits at the A-sump centervent. Oil weep holes are provided near the aft end of the compressor tiebolt. These weep holes keep oil out of the rotor by returning it to the sump. A rotor seal is provided hereto keep any weepage out of the seal air. This airflow keeps the compressor tiebolt relatively cool and uniformly clamped.

The remaining 30 percent of B-sump centervent air joins the inner balance piston seal leakage flow. It exits aft under the gas generator turbine wheels.

C-Sump. Centerventing the C-sump is a passage between the aft end of the PT shaft and a stationary standpipe built into the C-sump cover. Windage at the torque and speed-sensor teeth and in the annulus between the reference tube and the standpipe will return oil droplets to the sump. Weep holes are provided through the reference tube, shaft, and bearing spacer to allow oil from C-or A-sumps to enter the C-sump. C-sump cover scavenging through the C-sump housing removes remaining oil accumulation from the centerventing process during locked PT rotor operation and normal operation.

Oil Tank. After being routed through air-oil cooler pasages into the oil tank, air from the scavenge pumps flows down the radial drive shaft passage (Axis A) into the A-sump. Centerventing occurs after air enters the A-sump.

Accessory Gearbox. The accessory gearbox is vented through the Axis A pad via the mainframe oil tank and eventually through the A-sump. The AGB, tank, and A-sump essentially operate at the same pressure levels since they are interconnected.

LUBRICATION SYSTEM FOR T-62

The lubrication system consists of–

- Pump.
- Internal oil passages.
- Oil filter assembly.
- Falter bypass relief valve.
- Pressure switch (mounted externally).
- Oil jet ring,
- Sump.

The oil falter cavity, oil passages, and oil sump are built into the reduction drive housing. Two oil separator plates are installed on the accessory drive gear. Lubrication system capacity is 3 quarts and is a wet-sump system.

Oil is drawn out of the sump into the pump housing. The oil is carried between the pump gear teeth and pump housing wall. It is then forced through drilled passages to the oil filter housing.

Oil under pump pressure enters the bottom of the filter housing and passes through the filter element (from outside to inside). It then flows out the housing through a passage in the falter element cap. A relief valve in the filter element cap unseats at a differential pressure of 15 to 25 psi. This allows oil to flow from outside the filter element, through a passage in the falter element cap, to the falter outlet passage. If the filter element becomes clogged, the valve will open and allow oil to bypass the falter element.

From the filter, oil is forced into a passage to the system relief valve and to four oil jets. The oil jet ring, which encircles the high-speed input pinion, contains three of these jets. It sprays oil to the points where the high-speed input pinion meshes with the three planetary gears. One jet directs a spray between the end of the output shaft and the high-speed pinion to create a mist for lubrication of the rotor shaft bearings. The remaining gears and bearings are lubricated by air-oil mist created when oil strikes the planetary gears and high-speed pinion.

System pressure is maintained at 15 to 25 psi by a system relief valve. The valve regulates pressure by bypassing excessive pressure directly into the reduction drive housing. The bypassed oil strikes the inside surface of the air inlet housing, aiding in cooling the oil. Bypassed oil returns to the sump by gravity flow through an opening in the bottom of the planet carrier.

The normally open contacts of the low oil pressure switch close on increasing oil pressure at 5 to 7 psi. When the switch contacts close, the low oil pressure cirecuit is deenergized. At rated engine speed a drop in oil pressure below 5 to 7 psi will open the low oil pressure switch contacts. Through electrical circuitry, the drop in oil pressure will also close the main fuel solenoid valve and shut down the engine.